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LIQUID ELECTROLYTE BATTERY

The invention relates to a liquid electrolyte or electrolytic battery, which is preferably used in moving vehicles, such as e.g. cars, boats or aircraft.

The efforts more particularly made by the vehicle industry for lightweight construction also concerns the economizing of battery weight. However, there is at the same time an increasing demand for a higher battery power, because in addition to conventional energy for starting the vehicle, energy is also required for additional units such as electric window regulators, actuators or servomotors for adjusting seats and for the electric heating of the seats. It is desirable to keep the battery power at a constant high level over the entire battery life.

The prior art discloses various measures for increasing the power of a conventional lead acid battery. The term power is here understood to mean the capacity of the battery and the current output and consumption capability of the battery.

A particular problem arising with lead acid batteries is the optimum complete use of the electrode surface. Figs. 1 to 3 are intended to illustrate the problem known from the prior art. Fig. 1 is a sectional representation of a car battery 1 along its electrodes 2, which have a grid form in the present construction. The level of the battery acid 3 is designated 3a. Research has revealed that the chemical characteristics of the battery acid differ significantly in the areas designated a, b and c. Thus, in area a the acid concentration is too high, which leads to corrosion and ultimately to the disintegration of the plates. In area c the acid concentration is too low, i.e. the electrolytic characteristics necessary for the operation of the battery do not exist.

Only in the central area b does the acid have the optimum stoichiometric ratio. Thus, the existing electrode surface is not utilized in an optimum manner due to the inadequate acid characteristics in areas a and b. It is clear to the expert that the areas are not sharply defined in the manner shown.

In order to also improve the stoichiometric ratio in areas a and b, it is known from the prior art to circulate the battery acid, i.e. the electrolyte, in order to obtain a better intermixing. This simultaneously prevents the formation of deposits, which impair the function and life of the battery.

DE U1 9114909 discloses a storage battery, in which by means of the introduction of gas from a pressurized gas source, an electrolyte circulation is brought about. Due to their complicated construction such devices are unsuitable for vehicle batteries, particularly as additionally a pressurized gas source is needed.

The prior art also discloses electrolyte intermixing devices, which can be called hydrostatic pumps. Figs. 29a, 29b and 29c show the basic operation of such a device. Fig. 29a is a sectional representation of an electrolyte-filled battery box, which has a double bent plate 21, a portion of the angle projecting beyond the electrolyte surface. To facilitate understanding the electrode plates are not shown. If the battery box installed in a vehicle moves at a uniform speed v, i.e. the vehicle neither accelerates nor decelerates, the electrolyte surface is flat and horizontal. Fig. 29b shows that during a braking process, due to the mass moment of inertia, the electrolyte builds up to a wave in the travel direction and the electrolyte splashes over the upper portion of the plate edge. As now the liquid level between the angle and the casing wall is higher, according to fig. 29c the electrolyte flows downwards until the two levels have evened out. The arrows show the electrolyte flow direction.

This principle is inter alia described in US 4,963,444 US 5,096,787 and US 5,032,476. However, the inventors of the present invention have found that with the devices known from this prior art it is not possible to achieve an optimum electrolyte intermixing.

Therefore the problem of the invention is the provision of a liquid electrolyte battery for vehicles, in which the necessary higher battery capacity and life are to be achieved mainly through an improved electrolyte intermixing.

This problem is solved by the batteries according to claims 1, 10 and 15.

The advantage of the invention according to claim 1 is that the liquid electrolyte circulating device brings about a high degree of intermixing and consequently the battery capacity is significantly increased and simultaneously the battery life is lengthened. The liquid electrolyte circulating device has no free moving parts, whose movement could be impeded by electrolyte deposits. Therefore this device operates very reliably. In addition, the liquid electrolyte circulating device is very inexpensively manufacturable and can be readily integrated into the battery manufacturing technology. Unlike in the case of the prior art, hydrostatic electrolyte pumps, this device pumps the electrolyte from bottom to top. The inventors have proved that in this way intermixing can be significantly improved. Obviously it is advantage for intermixing purposes if the thicker bottom acid is forced upwards and runs out over the horizontal part of the intermixing device, in order to mix with the thinner surface acid.

In the case of a liquid electrolyte battery further developed in accordance with claim 2, parallel to the vertical edges is provided a second, plate-like element, in order to form a flow channel. Thus, the flow conditions can be set in a more clearly defined manner and optimized.

In a liquid electrolyte battery further developed according to claim 3, the first plate-like element and the second plate-like element are constructed in one piece as angles, so that in certain cases an easier assembly is possible.

In a liquid electrolyte battery further developed according to claim 4, in the vicinity of the upper edge of the first plate-like element is provided a first return flow preventer for preventing the return flow of a first electrolyte wave, which improves intermixing.

In a liquid electrolyte battery further developed according to claim 5, the return flow preventer is constructed as a web-like material extension of the first plate-like element, which is particularly cost-effective.

In a liquid electrolyte battery further developed according to claim 6, the return flow preventer is constructed as a flap valve, which particularly effectively prevents a return flow.

In a liquid electrolyte battery further developed according to claim 7, the liquid electrolyte circulating device is placed on both casing sides, which brings about an improved intermixing.

The advantage of the invention according to claim 10 is that through heat convection there is even a thorough mixing or intermixing when the battery is only slightly moved or not moved at all, the heating elements being so positioned that a powerful electrolyte flow can be produced.

According to claim 11 use is made of panel heaters, which are placed on or in the casing wall. If the battery is constructed from two cell groups, which are interconnected by a common partition, the heating means according to claim 12 can be placed on said partition located in the centre of the battery. Virtually no heat losses occur in this embodiment.

In claim 13 for the protection of the electrode plates a heat shield is provided, so that the electrolyte heated by the heating means does not pass directly to the electrode plates. In a particularly preferred embodiment according to claim 14, part of the mechanical circulating device is simultaneously used as a heat shield, so that both a mechanically caused and a thermally caused circulation of the electrolyte takes place.

The advantage of the invention according to claim 15 is that in the same way as for producing a convection by means of heating elements, an intermixing still occurs if the battery moves only slightly or is stationary. A Peltier element is highly suitable as the cooling element in accordance with claim 16.

The cooling involves the same effect, but it is brought about with different means. Thus, according to claim 17, there can be a combination with the mechanical circulating device.

Further measures and advantages of the invention can be gathered from the following description of embodiments in conjunction with the attached diagrammatic drawings.

Fig. 1 shows a side longitudinal section of a liquid electrolyte battery according to the prior art.

Fig. 2 shows the plan view of an open liquid electrolyte battery according to the prior art.

Fig. 3 shows the view of fig. 1, the liquid electrolyte battery undergoing an acceleration and the electrolyte level is inclined.

Fig. 4 shows a first embodiment of the invention.

Fig. 5 shows the first movement phase of the electrolyte surface during an acceleration.

Fig. 6 shows the second movement phase of the electrolyte surface after acceleration.

Fig. 7 shows the third movement phase of the electrolyte surface after the acceleration.

Fig. 8 shows a second embodiment of the invention.

Fig. 9 is a plan view of an open, inventive liquid electrolyte battery with a one-sided circulating device.

Fig. 10 shows a plan view of an open, inventive liquid electrolyte battery with a two-sided circulating device.

Fig. 11 shows a third embodiment of the invention in detail.

Fig. 12 shows a fourth embodiment of the invention in detail.

Fig. 13 shows a fifth embodiment of the invention.

Fig. 14 shows a sixth embodiment of the invention.

Fig. 15 shows another embodiment of the invention, where circulation takes place by heating.

Fig. 16 shows another embodiment of the invention, in which circulation takes place by cooling.

Fig. 17 shows a combination of mechanical and thermal circulation.

Fig. 18 shows a further combination of mechanical and thermal circulation.

Fig. 19 shows a combination of mechanical and thermal circulation by cooling.

Fig. 20 shows an angular mixing device with flow slots.

Fig. 21 shows an angular mixing device in conjunction with specially constructed flow channels.

Fig. 22 shows another form of a mixing device.

Fig. 23 shows another form of a mixing device.

Fig. 24 shows another form of a mixing device.

Fig. 25 shows another form of a mixing device.

Fig. 26 shows another form of a mixing device.

Fig. 27 shows another form of a mixing device.

Fig. 28 shows a further form of a mixing device, which automatically adapts to different acid levels.

Fig. 29 shows the closest prior art.

Figs. 1 and 2 serve for illustration purposes and show a liquid electrolyte battery according to the prior art with a casing 1 having side walls 1a, 1b, 1c, 1d, a casing bottom 1e and a lid 1f. Electrodes 2 are placed in vertically standing manner in the individual cells 1g, each of which contains a liquid electrolyte 3, which is approximately 1 cm above the upper edge of the electrodes 2.
Fig. 3 shows the representation of fig. 1, the liquid electrolyte battery undergoing an acceleration and the electrolyte level is inclined. This situation arises if the battery is e.g. installed in a car in such a way that the electrode plates extend in the direction of travel, which in the present example passes in the image plane from left to right. If the moving vehicle is decelerated, as a result of the mass moment of inertia of the electrolyte, it splashes in the direction of travel, which is only diagrammatically intimated by the sloping level. During travel there is only a slight electrolyte movement between the plates, without any significant intermixing occurring.

Fig. 4 shows a first embodiment of the invention. An angle 4-6 is inserted in such a way that a vertical side is parallel to the vertical plate edges. Its horizontal side is parallel to the upper edge 2a of the plates 2 in the vicinity of the level 3a of electrolyte 3.

If the above-described braking situation arises, the angle portion 4 prevents the described splashing movement of the electrolyte 3. Fig 5 diagrammatically shows the movements forced on the electrolyte by angle 4-6. Particular mention is made of the fact that the electrolyte in the vertical flow channel 5, which forms between the vertical side of the angle and the cell wall, is forced strongly upwards, which is diagrammatically represented by the upwardly directed arrows.

Fig. 6 shows the next time period, in which an electrolyte crest 3b has formed on the horizontal angle side and subsequently flows away as a wave in the arrow direction and runs out again at wall 1d and can again form an electrolyte crest (fig. 7).

The above statements make it clear that the angle and its spatial arrangement in the battery casing forces a cycle on the electrolyte, circulation taking place from bottom to top, so that a very intense intermixing occurs. Long-term testing has revealed that the electrolyte concentration in areas a, b and c is virtually the same and also has the correct stoichiometric ratio. Thus, also electrode portions a and c, which could only be partly utilized in conventional batteries, are now completely utilized.

Besides increasing the battery capacity, the invention has numerous further advantages. The improved intermixing ensures that there is no solid electrolyte deposit formation, which in conventional batteries reduces both power and service life. Particular mention is also made of the greatly improved cold starting characteristics of the inventive battery.

It is clear to the expert that the battery according to the invention has a preferred installation direction and this is chosen in such a way that there is an optimum circulation of the electrolyte. Thus, in a car the battery must be so installed that the electrode plates are oriented in the direction of travel.

Figs. 8 and 10 to 14 show further embodiments of the invention. Thus, fig. 8 shows on the angle 4-6 a web-like extension 4b, which can be vertical or inclined. This extension 4b prevents the rapid flow back of the electrolyte and consequently improves its intermixing.

Fig. 9 is a plan view of the opened battery with six cells, in which is in each case placed an angle 4-6.

As the battery, particularly in cars, is accelerated in both directions by braking and accelerating actions, intermixing is improved if two angles per cell are installed in oppositely directed manner, as shown in fig. 10 and as a result of the similarity of the action no further explanation is required by the expert.

Fig. 11 shows a further and/or additional possibility for preventing return electrolyte flow. As shown in fig. 11, on angle 4-6 can be placed a

flexible plate in such a way that a valve action occurs. If the electrolyte rises in the flow channel, the flexible plate engages on the wall to which it is fixed, i.e. the valve is opened. If the electrolyte flows back, the valve closes. The constructional details and the opening and closing phase are shown in figs. 11a to 11c and should require no additional explanations for the expert.

Fig. 12 shows a modification of the principle according to fig. 11. The structure and action of this flap valve are apparent from the drawings.

Fig 13 shows a second return flow preventer 9, which can be used in opposition to the direction of travel in car batteries. In place of a horizontal side, said device has a rearwardly open volume 10. If, according to fig. 7, a back-flowing wave is formed, it passes over the slope 10a and is held back by the open volume 10, so that the electrolyte sinks downwards along the vertical side and consequently an intermixing takes place.

It must be stressed that the return flow preventers shown can be further modified. Thus, at e.g. specific points in the angles openings can be provided, in order to prevent the formation of dead areas, i.e. areas where an inadequate intermixing takes place. The dimensioning of the return flow preventer for a specific battery type requires no inventive activity on the part of the expert when knowing the teaching involved. The expert will also take further intermixing-aiding measures, which are not expressly mentioned in the present invention. Thus, it is e.g. advantageous to so design the electrolyte flow paths that within the flows forced by the battery movement a limited flow resistance occurs, which can inter alia be achieved by very smooth walls and by the avoiding of projections where eddies can form.

Fig. 14 shows a double-sided embodiment according to fig. 10, where the two angles are linked by a perforated plate 11. This embodiment is advantageous from the assembly standpoint, because the electrode plates are held together in clamp or clip-like manner and can be easily automatically fitted. The action of the perforation is made clear to the expert on referring to fig. 5.

Fig. 15 shows another embodiment of the invention, where electrolyte circulation takes place by heating. For this purpose electric heating elements are located in the lower area of the battery box. On heating, the neighbouring electrolyte also heats and rises upwards and consequently brings about an intermixing. The heating elements are preferably of a very flat type, such as film or foil heaters. These heaters can be gathered from the prior art. As a result of the simple action, no further operational explanations are needed. It is stressed that the heaters 12 are not mainly used for heating the electrolyte, but instead for producing a convective flow, which brings about an intermixing. Therefore the heaters are not uniformly distributed over the entire bottom surface and are instead located at predetermined points, so that a very strong flow is produced.

If only a single heater or heaters with a high capacity are used, it may be necessary for the protection of electrodes 2 to provide a heat protection means between the latter and the heater. This heat protection ensures that the strongly heated electrolyte does not come into contact with the electrodes, because the latter could be damaged by the heat. In fig. 17 the heat protection is constructed as a flat plate, which can be dimensioned in the same way as the first plate-like element 6. It must be ensured that the heated electrolyte runs over the upper edge of the heat protection means or can pass through an opening in the plate.

The particular advantage of convective mixing by heat infeed is that the battery need not be moved. In the case of low external temperatures the electrolyte is simultaneously heated, which is also desirable.

If, for operational reasons, battery heating is not desired, then according to fig. 16 a convective mixing can also be brought about by a cooling element. Due to the oppositely directed convection, the cooling element is placed in the upper marginal area of the battery box, i.e. preferably below the electrolyte level.

Fig. 18 shows a combination of mechanical and thermal circulation by heating. The vertical side of the angle for mechanical intermixing

simultaneously serves as a heat protection during thermal intermixing. To permit the outflow of the heated, upwardly flowing electrolyte, the vertical side has holes 4c.

As in the embodiment according to fig. 18, fig. 19 shows a combination of mechanical and thermal circulation by cooling and the construction is readily apparent from the drawing. Peltier elements are used for cooling purposes. The function of this arrangement is apparent from the already explained contexts and the drawing.

Fig. 20 shows intermixing angles with flow slots 14, which improve the flow conditions for different electrolyte levels.

Fig. 21 shows an intermixing angle, which is suitable for forming different flow channels 5a. Fig. 21a is a perspective view of the intermixing angle and figs. 21b and 21c show the incorporated angle in plan view. In the arrangement according to fig. 21c, there is a U-shaped flow channel cross-section and in the arrangement according to fig. 21b two facing flow channels.

Fig. 22 shows an intermixing plate 4, with fig. 22a showing a side cross-section of a battery. The plate 4 is installed on the plate set and in the same way as all the upper angle portions 4 is preferably inclined slightly towards the battery centre. In this embodiment the battery wall takes over the function of the angle side 6.

Figs. 23 and 24 show intermixing devices, in which both angles are interconnected to form a U or box-like unit 15, 16. The slots 14 have an electrolyte inflow/outflow function.

Fig. 25 shows an intermixing angle, which has on the lower portion of the vertical angle side 6 a horizontal side 17, directed towards the battery centre and having a length L. This constructional measure makes it possible to optimize the flow conditions on introducing the electrolyte into the flow channel 5. The side 17 can also have holes or slots, if this leads to a flow condition improvement.

Fig. 26 shows an intermixing angle, whose flow channel is formed by two tubes 18.

Fig. 27 shows an intermixing angle similar to fig. 22. This angle has portions 19, which permit an anchoring of the angle in the plate set and simultaneously mechanically stabilize the set. This is merely a constructional detail.

Fig. 28 shows an intermixing angle with a movable side 4a, which is pivotably connected by means of a film hinge 20 to the vertical side 6. This movable side 4a floats on the electrolyte surface 3a. In the case of a suitable dimensioning, this arrangement improves the outflow of the electrolyte flowing upwards through the flow channel 6, so that intermixing is improved.

Taking account of the constructional and technological marginal conditions, the expert will choose one of the indicated variants and will optionally modify it without having to be involved in inventive activity.

By means of the embodiments described the expert can fully gather the technical teaching of the invention. It is clear that these embodiments can be further developed and modified or combined by an expert with the aid of the inventive teaching. Thus, even the embodiments not expressly mentioned or shown fall within the protective scope of the following claims.